BRITISH COLUMBIA

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Tsunami Notification Process Plan

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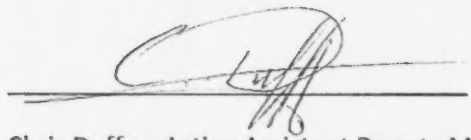

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Chris Duffy – Acting Assistant Deputy Minister
Ministry of Justice

Date

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Date	Amendment	Page #
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Tsunami Notification Process Plan

Purpose

The purpose of the *Tsunami Notification Process Plan* is to describe the roles, responsibilities and general procedures used by international, federal, provincial and key stakeholder agencies in the dissemination of tsunami messages within British Columbia (BC). These messages originate from the National Tsunami Warning Center (NTWC)[1] in Palmer, Alaska and various agencies disseminate these messages to government, media, key stakeholders and the public.

Scope

This document reviews the roles and responsibilities of key stakeholders involved in the distribution of tsunami messages in BC. It outlines the tsunami notification process, from the initiation of a tsunami message from NTWC to the reception of this information by the public. Key stakeholder agencies and the public must be aware of the appropriate actions to take in the event they receive a tsunami message from a credible source such as the NTWC and/or the agencies detailed within this document.

Appendices to this document include:

- A background of the tsunami threat in BC;
- Maps and descriptions of BC tsunami zones;
- Examples of the types of tsunami messages;
- Acronyms and terminology; and
- References for further tsunami related research and information.

Each identified stakeholder has internal standard operating procedures that detail their activities during a tsunami. Describing the procedures of each agency is outside the scope of this document. In addition, this document does not address emergency response actions following a tsunami that impacts BC.

This document is a hazard specific annex of the provincial Comprehensive Emergency Management Plan (CEMP). Please refer to the BC All-Hazard Plan (a component of the CEMP) for a detailed outline of the operational structure and responsibilities for a provincial all-hazard response.

Background

Tsunamis are a rare but serious threat to coastal communities in British Columbia. A zone of high seismic activity circles the Pacific Basin from the southernmost reaches of Chile to Alaska in the east (including the coast of BC) and from New Zealand through to Japan and the Aleutian Islands in the west. The "Ring of Fire," as it has become known, has the potential to generate earthquakes that produce large ocean waves called tsunamis that may threaten coastal settlements.

A tsunami is a series of large ocean waves and the first wave that reaches the coast may not be the largest. Tsunamis are generated by a sudden displacement of a large volume of water. This displacement can occur due to earthquakes, volcanic eruptions, meteors, slumps or coastal landslides. Underwater earthquakes are the cause of approximately 90% of global tsunamis but not all coastal or near-coastal earthquakes produce tsunamis. Scientists have determined that an earthquake must be at

[1] Formerly the West Coast and Alaska Tsunami Warning Center (WCATWC).

least a 7.0 magnitude or larger with significant land displacement to cause a tsunami. In fact, the majority of earthquakes that occur throughout the world are well below this threshold. Tsunami waves travel outward in all directions from the generating source. During a tsunami, the speeds of the waves diminish and their height increases as they enter shallow waters along a coastline, potentially causing inundation and damage to coastal communities.

On the west coast of North America, tsunamis are categorized as distant or local, depending on the location of the earthquake (i.e., point of origin) and the size of the area affected. A distant tsunami is generated from further than 1000 kilometers (kms) from the potential impact area whereas a local tsunami is generated from a source within 1000 kms. While a distant tsunami should allow time for an official tsunami message to be given, a local tsunami can reach the shoreline in minutes and may not allow for an official warning to take place. In this case natural signs, such as the strong shaking from the earthquake, a receding ocean, or a loud roar-like sound, may be your only warnings to take action.

Specific Considerations Associated with Tsunami Notification

- Public education is the most effective way to prevent loss of life due to tsunamis.
- Awareness and education are key elements of tsunami planning and require continuing efforts from all levels of governments and individuals that are at risk of a tsunami.
- Clear and consistent messaging is needed to ensure public confidence, to keep the public informed of risks and to avoid confusion during events.
- NTWC does not differentiate the tsunami risk between the exposed west coast of BC and the relatively protected Georgia Strait. It is for this reason that EMBC issues BC-specific tsunami messages that will include information on alert levels for the five established BC tsunami zones (see Tsunami Zone Maps in Appendix 3).
- NTWC estimates expected tsunami wave heights based on earthquake parameters, which may be modified as new information is analysed and observed data is received. As a result, tsunami alert levels may change as new information is confirmed.
- Local authorities are responsible for notifying their residents of tsunami risks, disseminating tsunami messages to residents during an event and for having plans to evacuate low-lying areas.
- There is a very low risk of a distant tsunami impacting the Strait of Georgia; however, a local tsunami could be generated by an earthquake or landslide in the local area.
- Local tsunamis may arrive onshore before a tsunami message can be initiated. If individuals in coastal areas feel strong shaking, they should take cover under a sturdy object until the shaking stops and then move to higher ground. Tsunami notification stakeholders in at-risk areas should decide if they will activate their tsunami plans without waiting for a tsunami message.
- Tsunami messages will be received at varying times depending on the method of notification. For example, social media will relay tsunami messages sooner than the EMBC voice activated telephone system. If possible, stakeholders should have multiple methods of receiving tsunami messages.
- Individuals and families that live near BC shorelines should plan for what they will do during and after a tsunami.

Alert Levels

Tsunami messages issued by NTWC and EMBC use the same alert levels. They are Warning, Advisory, Watch, Information Statement and Cancellation. Each has a distinct meaning relating to recommended local emergency response activities. The following chart outlines the meaning of each alert level and recommended action. It is important to note that during a tsunami, updated information may result in a change in the alert levels.

Alert Level	Threat	Suggested Action
Warning	Inundating wave possible	Full evacuation
Advisory	Strong currents likely	Stay away from the shore
Watch	Danger level not known yet	Stay alert for more information
Information Statement	Minor waves at most	No action required
Cancellation	Tide gauges show no wave activity	Confirm safety of local areas

From the highest to the lowest threat, the alert levels are:

- Warning;
- Advisory;
- Watch;
- Information Statement; and
- Cancellation.

Warning

A "Warning" is the highest level of tsunami alert. Warnings are issued due to the imminent threat of a tsunami from a large undersea earthquake, or following confirmation that a potentially destructive

tsunami is underway. They may initially be based only on seismic information as a means of providing the earliest possible alert. Warnings suggest the evacuation of coastal areas within the area.

Advisory

An "Advisory" is the second highest level of tsunami alert. Advisories are issued due to the threat of a tsunami that has the potential to produce strong currents dangerous to those in or near the water. Significant inundation is not expected for areas under an Advisory but coastal zones may be at risk due to strong currents. Appropriate actions by local emergency management personnel may include closing beaches and evacuating harbours and marinas.

Watch

A "Watch" is the third highest level of tsunami alert. Watches are based on seismic information, without confirmation that a destructive tsunami is underway. There is a potential threat to a zone under a tsunami Watch but communities have time to prepare. Emergency management personnel and coastal residents should prepare to take action in case the Watch is upgraded to an advisory or warning.

Information Statement

An "Information Statement" is issued when an earthquake has occurred and there is no threat of a destructive tsunami affecting BC. Information Statements may be used to prevent unnecessary concern when an earthquake has occurred but there is no tsunami threat.

Cancellation

A "Cancellation" cancels any previously issued tsunami messages. It is issued when there is no longer observed evidence of tsunami waves at tide gauge stations. Local conditions may differ from those at tide gauge stations and local authorities should determine the safety of coastlines. Cancellations are the final tsunami message issued by EMBC.

For further information regarding the NTWC tsunami alert levels, visit the NTWC website at:
http://wcatwc.arh.noaa.gov/?page=message_definitions

NTWC Tsunami Notification

NTWC's area of responsibility includes the coasts of California, Oregon, Washington, British Columbia and Alaska, along with the other areas of the continental US, Canada, Puerto Rico and the US Virgin Islands. The Pacific Tsunami Warning Center, located in Hawaii, issues tsunami messages for other areas of the Pacific and acts as a backup for the NTWC if it is not operational.

When an earthquake occurs, there is no immediate method to determine if a tsunami has been generated. Scientists at NTWC note the estimated magnitude and location of the earthquake's epicentre to determine if there is a potential for a tsunami. Based on this limited information, an initial tsunami message is issued. The NTWC issues an initial tsunami message within a few minutes of the earthquake via satellite, email, text messaging, fax and Twitter to key responding agencies and individuals.

The NTWC then tracks the arrival of tsunami waves through a network of tide gauge stations and buoys in the open ocean that respond via satellite link. NTWC continues to issue messages as information is updated. As more information is gathered and the risk is understood more clearly, tsunami alert levels may change.

The NTWC messages identify:

- Alert levels for the NTWC area of responsibility;
- Earthquake parameters;
- Anticipated impacts based on alert level;
- Recommended actions within the alert area;
- Forecasted tsunami start times at pre-defined locations in the alert area; and
- Forecasted or observed tsunami wave heights at pre-defined locations in the alert area.

This information is subject to verification by NTWC and may change throughout a tsunami event.

BC receives NTWC messages based on three pre-defined north-south breakpoints that geographically divide the BC coastline. These breakpoints are the BC/Alaska border, the north tip of Vancouver Island and the BC/Washington border. The messages provided by NTWC are considered accurate for BC; immediate actions by emergency managers and responding agencies may be necessary based solely on NTWC messages.

Provincial Emergency Notification System

NTWC messages are transmitted to the 24/7 Emergency Coordination Centre (ECC) at EMBC and regular conference calls are held between NTWC and EMBC for situational updates during a tsunami event. EMBC rebroadcasts NTWC messages and issues BC-specific tsunami messages through the Provincial Emergency Notification System (PENS). To ensure all coastal communities receive appropriate tsunami messages, EMBC has divided coastal BC into five (5) zones. For a full description of BC Tsunami Zones see Appendix 3. EMBC distributes ongoing tsunami messages as more information becomes available.

If known, the tsunami message will contain the following information:

- A brief description of the event including location and earthquake magnitude;
- Whether or not it is known that a tsunami has been generated;
- The BC tsunami zone(s) placed in Warning, Advisory, Watch, Information Only or Cancellation; and
- Recommended actions.

EMBC is the provincial lead for tsunami notification to emergency management stakeholders in BC; however, many agencies collaborate to disseminate tsunami messages to as many people as possible in as short a time as possible. PENS consists of multiple methods and partner agencies to ensure timely and accurate tsunami messages. These methods include:

- EMBC social media twitter feed and EmergencyInfoBC blog;
- EMBC direct telephone calls;
- EMBC email;
- EMBC interactive voice telephone;
- EMBC fax;
- Provincial Emergency Radio Communications Service (PERCS);
- Environment Canada Weatheradio and Weather website; and
- Marine Communication and Traffic Services/Canadian Coast Guard - Channel 16 marine radio transmissions.

Receipt of a tsunami messages via any of the above sources, or directly from NTWC, should be considered a PENS message. Recipients should receive tsunami messages from a number of sources to

ensure redundancy. The objective is for each recipient to receive the message at least once. Emergency management stakeholders who are interested in receiving tsunami messages should ensure that they are able to receive these messages in multiple ways.

Stakeholders that receive tsunami messages through PENS should disseminate the information to their networks in order to ensure widespread notification according to their previously established local plans.

Components of PENS

Social Media:
EMBC utilizes social media to alert British Columbians to a tsunami threat by amplifying messages and verified information from NTWC and EMBC officials. The primary channels used are Twitter (@emergencyinfobc) and the Emergency Info BC blog. Social media communicates in near real-time; therefore, tsunami messages and updates will most likely be received via @emergencyinfobc before the other PENS notification methods.

Direct phone calls:
EMBC Regional offices have established contact lists with emergency management personnel in BC coastal communities. Phone calls are prioritized based on the arrival time of the tsunami and historical tsunami impacts. This is a reliable person-to-person system that allows for confirmation that the tsunami message is received.

Email:
EMBC uses email to contact emergency management personnel in coastal areas. This method is fast, but requires redundancies because the recipient may not view the email in a timely manner. Note that individuals may be able to adjust their personal email system settings to allow tsunami messages to be forwarded as a text message to their cellular phones or to have an audible tone when they are received.

Interactive Voice Response Telephone Auto-dialer system:
EMBC disseminates BC-specific tsunami messages through an automated phone system to predetermined emergency management stakeholders. This web-based system can be accessed remotely and can dial many phone numbers in a short period of time. Although it may be slower to be activated and received than other methods, it is an intrusive alert and allows for modification of the messages to provide customized information specific to BC.

Fax:
Fax servers have the ability to send hundreds of faxes rapidly. For some remote communities, where cellular service is unreliable or unavailable, fax is a valuable form of communication.

Provincial Emergency Radio Communications Service (PERCS):
During a tsunami event, EMBC will broadcast tsunami Watch, Advisory and Warning messages by amateur radio, ensuring coastal communities expedited and redundant delivery of tsunami information. If existing communication technologies fail during an emergency or disaster, PERCS can provide timely and accurate information during response through radio technologies.

Environment Canada

Environment Canada utilizes its infrastructure and expertise in national weather alerting to disseminate tsunami messages in BC. On behalf of EMBC, they issue BC specific tsunami messages through a variety of channels including www.weather.gc.ca, Weatheradio and subscription media and emergency management web platforms.

Canadian Coast Guard – Marine Communication and Traffic Services

The Canadian Coast Guard, Marine Communications and Traffic Services division is a key agency for at-sea tsunami notification in BC. On behalf of EMBC, they issue tsunami messages directly to vessel traffic and remote coastal communities on Marine Channel 16.

Local Governments

Once local government (local authorities and First Nations) emergency managers and program staff receive a tsunami message and are made aware of a tsunami risk to their community they should begin notifying response agencies, the public and media in their jurisdiction according to their emergency plans. To ensure appropriate actions are taken, emergency planning and hazard assessments are crucial in avoiding unnecessary public panic.

First responders, emergency officials and elected officials at the local level should prepare and distribute tsunami updates to the public through local media about their specific circumstances and activities (e.g., evacuation orders). Local emergency information may include how to prepare to evacuate, what routes to take and the location of reception centres. If necessary, local governments should also work closely with the local police to issue evacuation notices in high-risk areas. The local governments determine when it is safe for their residents to return.

Local governments should anticipate the need to respond to public enquiries about tsunami status and should provide ongoing public information in order to ensure public safety. Updates via social media, local government website, radio and television are the primary methods for keeping the public informed.

Media

Media are important partners in the delivery of tsunami messages and public safety information. Media outlets play a role that includes public messaging, province-wide awareness and the notification of the general public. Their role exists regardless of their target audience (provincial, regional and local) or chosen mode of communication (television, radio, print or online). Local media outlets often work in partnership with emergency programs to broadcast local information as it is supplied.

Roles and Responsibilities

Within BC, numerous agencies and all levels of government have roles and/or responsibilities in the tsunami notification process.

National Tsunami Warning Center (NTWC)

NTWC messages are the primary mechanism for communicating which areas of BC's coastline are at risk in the event of an undersea earthquake. NTWC determines if an earthquake has the potential to generate a tsunami (i.e., the earthquake parameters influence the alert level). If appropriate, NTWC issues the tsunami messages to EMBC, placing certain portions of the coast in Warning, Advisory and/or Watch status.

Provincial Ministries

Ministry of Justice, Emergency Management BC (EMBC)

EMBC is the primary BC contact for the NTWC and is responsible for coordinating the dissemination of provincial tsunami messages to local governments, media and other emergency management stakeholders.

- Maintain a 24/7 Emergency Coordination Centre (ECC) for receiving and disseminating tsunami messages;
- Activate the provincial emergency management structure in response to a tsunami threat. This may include activation of one or more Provincial Regional Emergency Operation Centres (PREOCs) and the Provincial Emergency Coordination Centre (PECC);
- Prepare and distribute BC-specific tsunami messages to media, local governments, federal agencies, First Nations, police, provincial government ministries and other key stakeholder agencies;
- Support local governments' emergency management programs and ensure receipt of critical tsunami messages and other pertinent information;
- Produce provincial situational reports, which will include tsunami information, information on the activation of the provincial emergency management structure and activities of local governments;
- Post information utilizing social media platforms; and
- Maintain lists of key contact information for agencies, media and local governments in BC.

Government Communications and Public Engagement (GCPE)

The primary role of GCPE for tsunami notification is to support EMBC by amplifying its provincial tsunami messaging to online audiences, the provincial government leadership and through media access. Government Communications and Public Engagement (GCPE) HQ and Ministry of Justice division has media relations staff available to respond to media enquiries. In addition, GCPE will deploy Temporary Emergency Assignment and Management System (TEAMS) members to provide support to the PECC and PREOCs as needed for media relations, citizen engagement, ministerial and public communication efforts.

Ministry of Health (MoH)

The primary role of the Ministry of Health (MoH) for tsunami notification is to ensure that health system partners have received relevant tsunami messages and have activated plans, as appropriate. MoH activities include:

- The Ministry of Health's (MoH), Emergency Management Unit (EMU) Duty Officer, Health Authority, BC Ambulance Emergency Management representatives and coastal hospital switchboards receive EMBC tsunami messages.
- Health Emergency Management (HEM) leads contact Directors, Executive and Local Managers and activate Health Facility or Health System Regional Response Plans as required.
- The MoH Duty Officer and Executive Director (EMU) will do a comprehensive (health) situation assessment in concert with HEM leads and ensure MoH Executive are fully briefed.

Federal Government

Aboriginal Affairs and Northern Development Canada (AANDC)

The primary role of AANDC is to support on-reserve First Nations communities in the four pillars of emergency management: mitigation, preparedness, response and recovery. AANDC will:

- Receive tsunami messages from EMBC;
- Maintain a list of up-to-date emergency contact information and share it with EMBC and other emergency response agencies as appropriate;
- Encourage First Nations communities to register directly for tsunami messages and ensure the contact information used by EMBC is current;
- Work with EMBC and local governments to provide regular status reports to Chiefs and Councils, and to the community as a whole;
- Liaise between the First Nations communities, EMBC, local governments and other emergency response agencies as appropriate; and
- Work with EMBC to provide accurate, relevant reports to assist in future decision-making.

Canadian Coast Guard (CCG) - Marine Communications & Traffic Services (MCTS)

The primary role of CCG MCTS program is to broadcast timely tsunami information to mariners and BC coastal communities via short and long-range marine radio frequencies such as VHF Channel 16 and MF 2182 kHz. CCG will:

- Establish contact (email/phone) with EMBC;
- Confirm receipt of tsunami messages with all MCTS centres, Joint Rescue Coordination Centre (JRCC) and CCG Regional Operations Centre (ROC) and manages the coastal broadcast schedule for all five MCTS centres to ensure comprehensive coverage;
- Broadcast NTWC messages upon receipt and record on the Continuous Marine Broadcast (CMB);
- Broadcast EMBC messages and Environment Canada bulletins upon receipt and record on the Continuous Marine Broadcast (CMB) and suspend broadcast of NTWC material, unless directed otherwise;
- Initiate local maritime industry and community call-out procedures per MCTS centre directives;
- Monitor marine radio channels and frequencies and pass observation reports to NTWC, CHS and EMBC; and
- Broadcast *Cancellation* messages upon receipt.

- Complete a post-event summary report for distribution to EMBC, NTWC, CHS and MCTS regional office.
- Advise Department of Fisheries and Oceans Radio Room and CCG Regional Operations Centre (done by the Regional Marine Information Centre (RMIC)).
- Manage all CCG stations and on-water assets (done by the Regional Operations Centre (ROC) and Joint Rescue Coordination Centre (JRCC)).

Canadian Hydrographic Service (CHS) and Department of Fisheries and Oceans Canada (DFO)

CHS and DFO will:

- Receive BC tsunami messages from EMBC;
- Apply local and actual ocean and tidal conditions to data contained in tsunami messages to determine if there is a significant threat to coastal communities, vessels and float planes; and
- Liaise with EMBC and provide anticipated wave height information, observed wave arrival times and observed wave heights at BC coastal tide gauge stations.

Department of National Defence (DND)

The primary role of the Department of National Defence is to respond effectively to tsunami alerts in order to maintain the critical capabilities required to defend Canada and be prepared to conduct life-saving activities in support of other agencies. DND will:

- Receive tsunami messages from NTWC, Environment Canada and EMBC;
- Joint Task Force Pacific (JTFP) Regional Joint Operations Centre (RJOC) will maintain communications and situational awareness with EMBC.
- With activation of the Provincial Emergency Coordination Centre (PECC), JTFP will provide a Liaison Officer for coordination purposes. Additional staff may contribute to integrated response planning with EMBC and other federal partners should the situation require.
- JTFP will be responsible for informing and directing the activities of all Canadian Armed Forces bases, stations, assets and personnel in B.C.
- The JTFP RJOC will advise the Joint Rescue Coordination Centre (JRCC Victoria) which is co-located with JTFP Headquarters.

"E" Division, Royal Canadian Mounted Police (RCMP)

E-Division will:

- Receive BC tsunami messages from EMBC;
- Rebroadcast BC tsunami messages received from EMBC to all RCMP detachments and/or RCMP Operational Communication Centres and Municipal Police Departments in affected coastal areas;
- RCMP detachments in affected areas will activate their Emergency Operations Plan as required and in partnership with local authority emergency programs.
- To avoid duplication of efforts, the RCMP Detachment Emergency Operation Plan will operate in accordance with local governments within their jurisdiction (in areas where mutually agreed upon plans are in place).

Environment Canada (EC)

EC will:

- Receive BC tsunami messages from NTWC;
- The Pacific Storm Prediction Centre of Environment Canada will, using NTWC information and preset instructions from EMBC, create a tsunami message that will flow through Environment Canada's dissemination system to data circuits (DND, CCG, Media, etc), Datamart, subscription media and emergency management web platforms, www.weather.gc.ca and Weatheradio transmitters.
- Weatheradio transmitters will broadcast pre-scripted tsunami messages in both English and French, triggering the automatic activation of special radio receivers within range of the Weatheradio signal.
- Tsunami messages will flow through www.weather.gc.ca in the same fashion as other weather warnings, providing colour fill to battle boards, banners on city pages, RSS feeds and appropriate text sections.
- Environment Canada will update and eventually end tsunami messages as per instruction from EMBC and/or NTWC.

Natural Resources Canada (NRCan)

Natural Resource Canada's primary role is to provide data and technical information for tsunamigenic seismic events. NRCan will:

- Receive BC tsunami messages from EMBC.
- The Geological Survey of Canada is available on a 24-hour basis to provide advice on potentially tsunamigenic earthquakes.

Parks Canada (PC)

Parks Canada will:

- All National Parks on the BC coast receive tsunami messages from the Parks Canada 24-hour dispatch center located in Jasper National Park, Alberta. The dispatch center receives BC tsunami messages from EMBC.
- Once a BC Tsunami Message has been received, the duty officer or manager on call will mobilize the Integrated Visitor Safety Team to ensure the safety of park visitors and staff and to evacuate people as required.
- In addition to being responsible for the safety of visitors and staff within a Parks Canada boundary, Parks Canada staff may also assist other agencies in and outside the park during an emergency as noted in Mutual Aid Agreements.

Public Safety Canada (PS)

The primary role of Public Safety Canada is to provide support to the Province and Government Operations Centre and to coordinate situational awareness and requests for federal assistance. PS activities include:

- The Government Operations Centre (GOC) in Ottawa receives messages from NTWC and the BC Regional Office (RO).
- The RO receives BC tsunami messages from EMBC, the GOC and NTWC, and distributes notices and reports as appropriate to other federal departments and agencies.

- PS coordinates the federal government response to an emergency event, including the establishment of a Federal Coordination Centre in Vancouver, if required, and facilitates requests for federal assistance in support of the province.
- A PS representative is present at the PECC during a tsunami Warning and/or when requested.

Local Government

The primary role of local authorities is to notify individuals within their jurisdiction of tsunami watches, advisories, warnings and cancellations. They should also be aware of tsunami information statements. Local governments may also:

- Perform an analysis of the tsunami risk in their jurisdiction as part of community emergency planning;
- Receive and acts on tsunami messages that could impact their jurisdiction;
- Alert populations in their jurisdiction in the manner specified in local plans;
- Activate local emergency response plans or emergency operation centres as required;
- Provide direction to the public in their jurisdiction;
- Distribute situation updates to the public;
- Issue an "All-Clear" message;
- Coordinate evacuations in partnership with local first responders; and
- Determine if evacuations are required and activate reception centres as necessary.

Media

The primary role of the media is to provide up-to-date, accurate information to the public in the interest of public safety. This includes broadcasting tsunami messages and public information to areas under threat.

Appendix 1: Tsunami Background

A tsunami is a rare but serious threat. A zone of high seismic activity circles the Pacific Basin from the southernmost reaches of Chile to Alaska in the east and from New Zealand through to Japan and the Aleutian Islands in the west. The "Ring of Fire," as it has become known, has the potential to generate earthquakes that produce large ocean waves called tsunamis that may threaten island and coastal settlements.

A tsunami is a series of ocean waves generated by the sudden displacement of large volumes of water by thrust-type submarine earthquakes, submarine volcanic eruptions, slumps or coastal landslides or meteors. Underwater earthquakes are the cause of approximately 90% of global tsunamis but not all coastal or near-coastal earthquakes produce tsunamis. Scientists have determined that an earthquake must be at least a 7.0 magnitude or larger with significant land displacement to cause a tsunami. In fact, the majority of earthquakes that occur throughout the world are well below this threshold.

Tsunami waves travel outward in all directions from the generating source. Waves undergo accelerations or decelerations while passing over the ocean bottom. The speed of the wave will vary depending on the depth of water. In the deep ocean, tsunami waves can reach speeds of more than 800 kilometres per hour. The distance between waves can be as great as 650 kilometres, with wave heights that range from 30 to 60 centimetres. In the deep ocean, a tsunami produces only a gentle rise and fall of the sea surface. These waves will not likely be noticed by ships at sea or by aircraft flying above.

As waves enter the shoaling (shallow) waters along a coastline, their speed diminishes, their height increases and the waves develop closer together. The unique shape of the coastline and ocean floor will influence the height of the tsunami waves and the potential for damage. Therefore, tsunami waves may be small in one location on the coast and much larger at another. Tsunami waves do not look like typical wind-driven waves, they most often move inland as a violent surge of fast-rising water rather than a wave with a smooth curling front.

Onshore there are often physical indications that an earthquake has generated a tsunami, such as:

- an abnormal recession of water;
- a rapid rise in water level;
- a low rumbling noise; and/or
- a bore (wave with a violently churning front).

Both the advancing and receding waves can cause damage. The degree of damage and destructive effects are dependent on the size of the tsunami wave, the unique shape of the coastline and the location of community infrastructure. At some locations, the advancing turbulent front will be the most destructive part of the wave. In other locations, the greatest damage will be caused by the outflow of water back to the sea between waves. A tsunami is a series of waves that can impact coastlines for extended periods of time. The first wave may not be the largest wave in the series.

Appendix 2: Overview of the Tsunami Threat to British Columbia

On the west coast of North America, tsunamis are categorized as distant or local, depending on the location of the earthquake (i.e., the point of origin) and the size of the affected area.

Distant Tsunami

The areas in British Columbia most vulnerable to distant tsunamis are the inlets along the west coast of Vancouver Island, coast of Haida Gwaii, and the mainland coast between the southern tip of Haida Gwaii and the northern tip of Vancouver Island. The Strait of Georgia is sheltered by Vancouver Island and would not be impacted by a distant tsunami.

Pacific-wide tsunamis are rare but have great destructive potential because the waves can be large and impact a wide coastal area. For example, on March 11, 2011, a 9.0 magnitude earthquake in Japan caused a tsunami that had significant impacts across the Pacific Basin from Chile to Alaska, New Zealand and the Philippines. An earthquake in Prince William Sound, Alaska on March 27, 1964, resulted in a well-documented tsunami with a wave height of 4.1 metres in Pt. Alberni, BC. The tsunami caused extensive damage and was the trigger for the establishment of the NTWC.

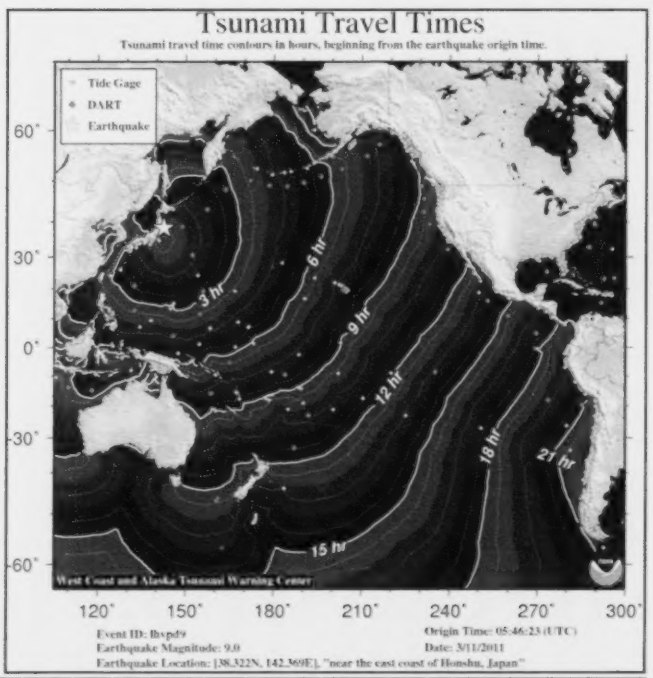

Figure 1: Tsunami travel time map from the Japan tsunami of March, 2011 (NOAA, 2011). Note that tsunami waves were observed on BC's coast for many hours after the first wave arrived.

Local Tsunami

A local tsunami is defined as a tsunami from a source within 1000kms of the area of potential impact. A local tsunami can reach the shoreline in minutes or as long as two hours. The location and travel time of local tsunamis may not allow for an official warning to take place and impacts may be limited to the local area or be pacific-wide.

For local tsunamis, there will likely be no official tsunami warning issued because their travel time to coastal areas is so short. If a local earthquake occurs, the shaking is your warning. Those living in low-lying coastal areas should assume that a tsunami has been generated. If individuals live in a tsunami risk area, once the shaking has stopped, they should move to higher ground immediately.

Tsunamis generated by landslides can occur independently or in association with an earthquake. On December 4th, 2007 at Chehalis Lake, near Chilliwack, the Cohoe Creek landslide was triggered by a significant rainfall event. The landslide produced waves that were reported to be 10 meters in height, destroying two campgrounds at the opposite side of the lake. In April 1975, Kitimat Inlet experienced an underwater landslide that generated an 8 meter wave that damaged nearby dock facilities.

Cascadia Subduction Zone

The Cascadia Subduction Zone presents the highest tsunami threat to British Columbia. It is located approximately 150 kilometres off the coast of BC and stretches from Northern Vancouver Island to Northern California. A large magnitude earthquake along the Cascadia Subduction Zone has the potential to generate a tsunami that impacts the BC coast and the entire Pacific Basin. This event would not allow enough time for an official emergency warning to be sent out before the first wave impacts the BC coast. In this case, the shaking from the earthquake itself would warn people in areas at risk to tsunami to move to higher ground. In a Cascadia earthquake, it is estimated to take about twenty minutes for the first tsunami waves to impact the outer coast of Vancouver Island.

Past Tsunamis in BC

Tsunami Source Location	Travel time of initial impact to BC (approx.)	Examples (location, year)	Potential Impact to BC
Alaska and Aleutians	1-6 hrs	Alaska, 1964	High
Japan	8-10 hrs	Japan, 2011	Moderate
S. Pacific	9-12 hrs	Samoa, 2009	Low
S. America	15-17 hrs	Chile, 2011	Low
C. America	6-8 hrs	El Salvador, 2012	Low
Cascadia Subduction Zone	20-30 mins	Off Southwest BC coast, 1700	High
Haida Gwaii	5-10 mins	Haida Gwaii, 2012	Moderate

Appendix 3: Tsunami Zone Maps for Coastal British Columbia

It is important to know that NTWC messages refer to BC coastal areas in terms of breakpoints. For information specific to the NTWC breakpoints, visit the website:
http://wcatwc.arh.noaa.gov/documentation/ops/opsmanual.pdf.

To ensure all BC communities receive appropriate tsunami messages, EMBC has divided coastal BC into five (5) zones. Each zone includes all islands and inlets within the zone description. After the first tsunami message has been forwarded from NTWC, EMBC will issue BC tsunami messages with information specific to BC zones. It is critical that communities know and recognize their designated zone in order to fully understand the information contained in the BC-specific tsunami messages.

For BC tsunami zone maps, visit the website:
http://www.embc.gov.bc.ca/em/hazard_preparedness/Tsunami_Notification_Zone_Maps.html

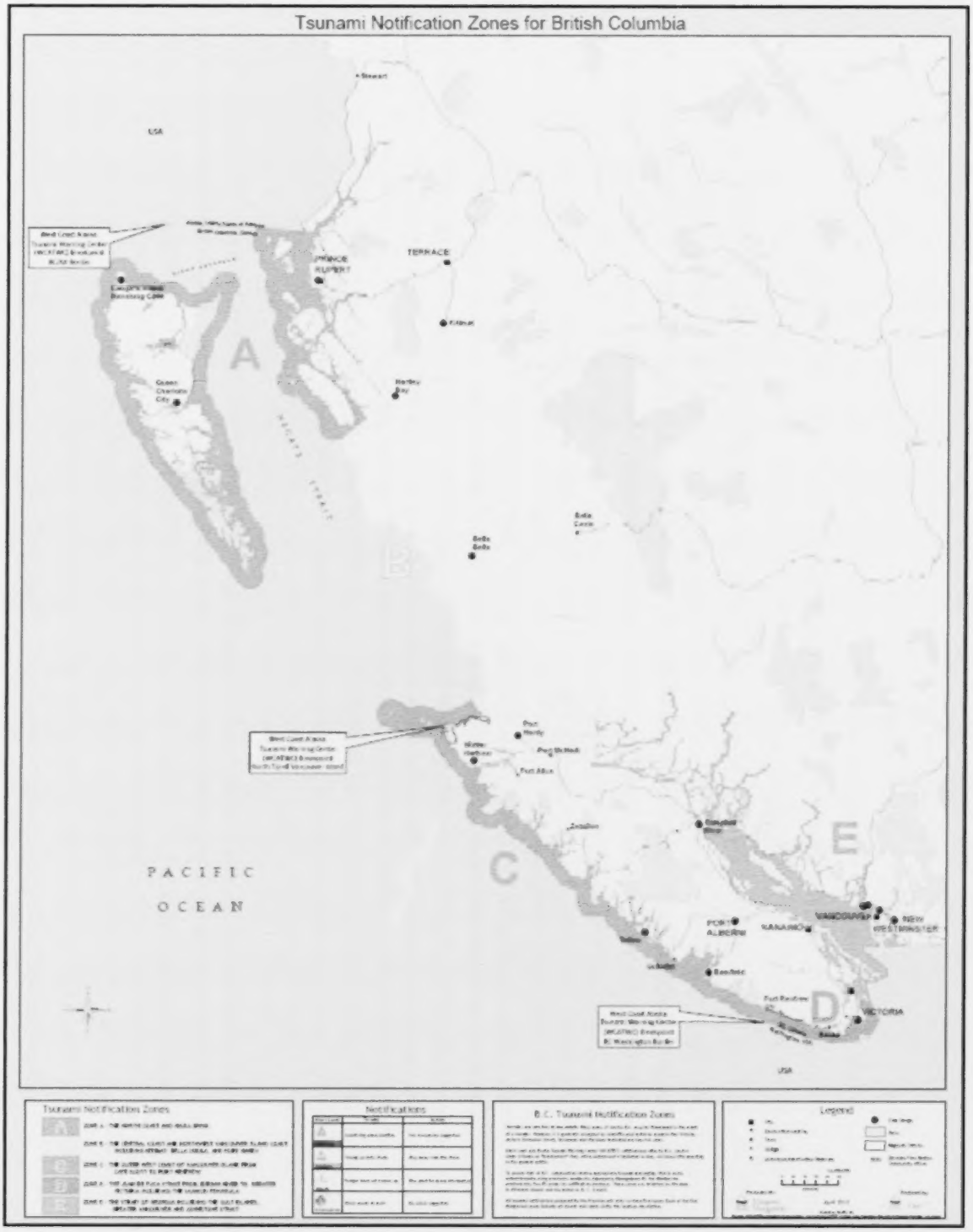

Figure 2: Map of all BC Tsunami Zones

Zone A

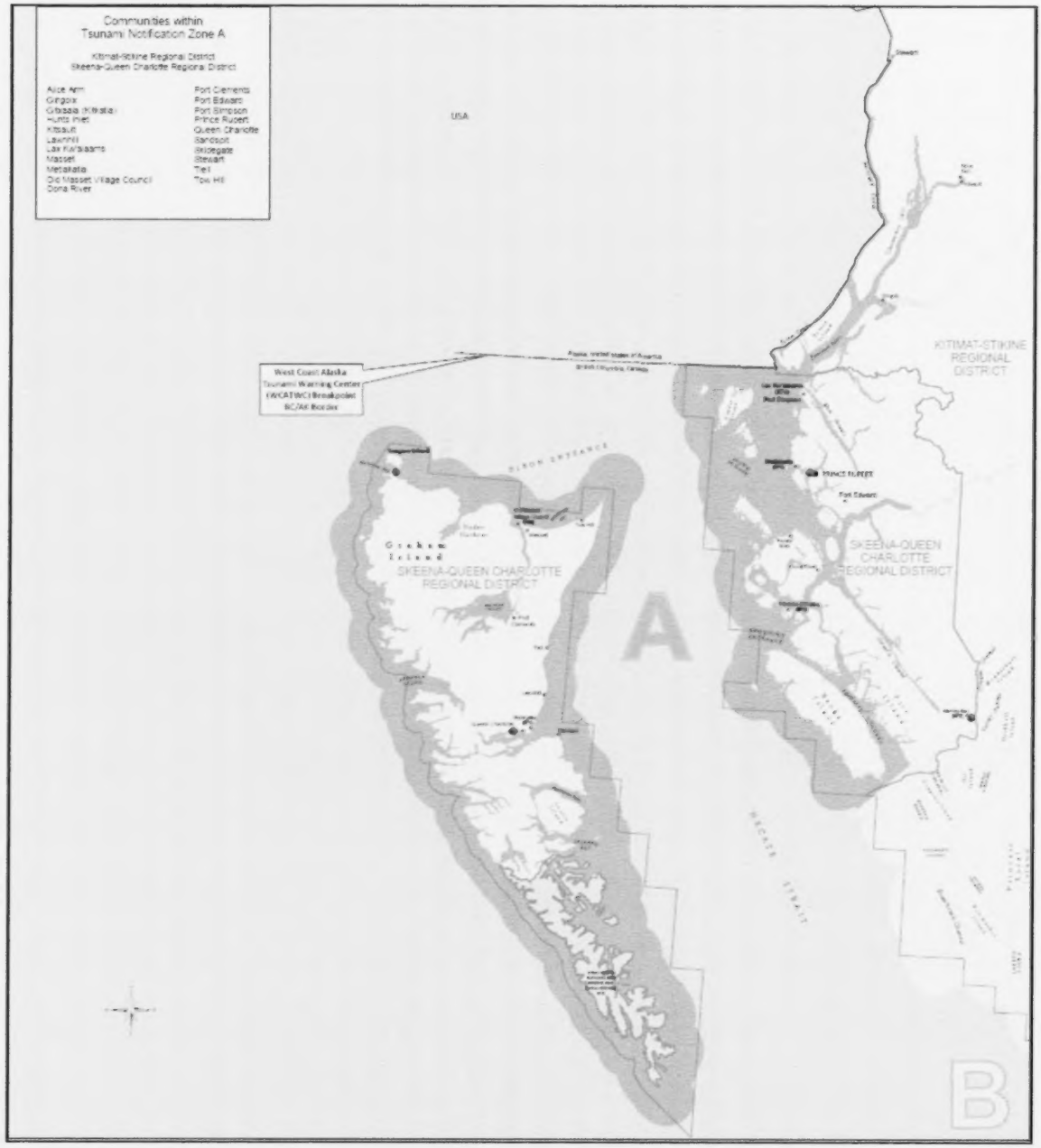

Figure 3: Zone A, the North Coast and Haida Gwaii

Zone B

Figure 4: Zone B, the Central Coast and Northwest Vancouver Island Coast including Kitimat, Bella Coola and Port Hardy

Zone C

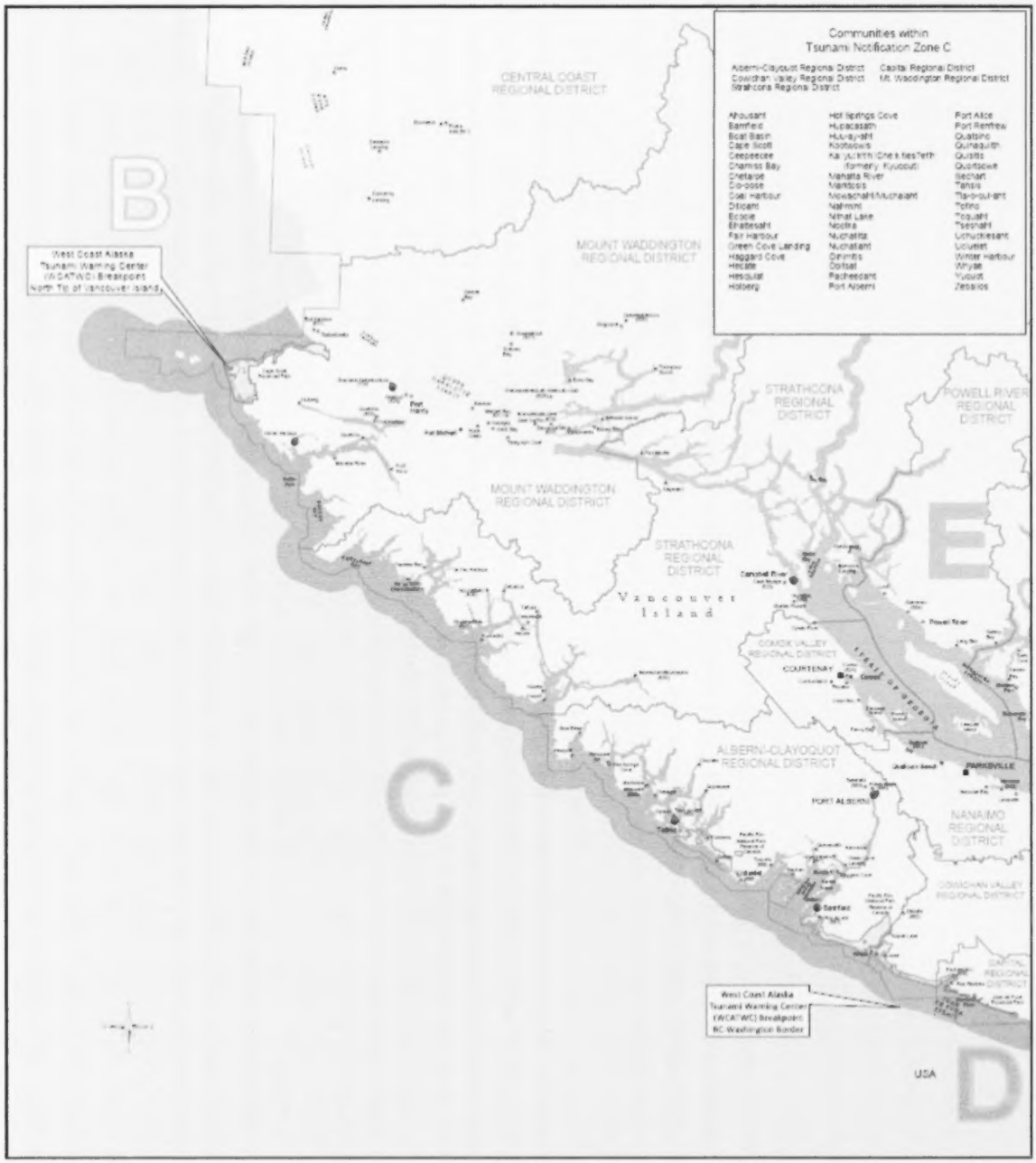

Figure 5: Zone C, the Outer West Coast of Vancouver Island from Cape Scott to Port Renfrew

Zone D

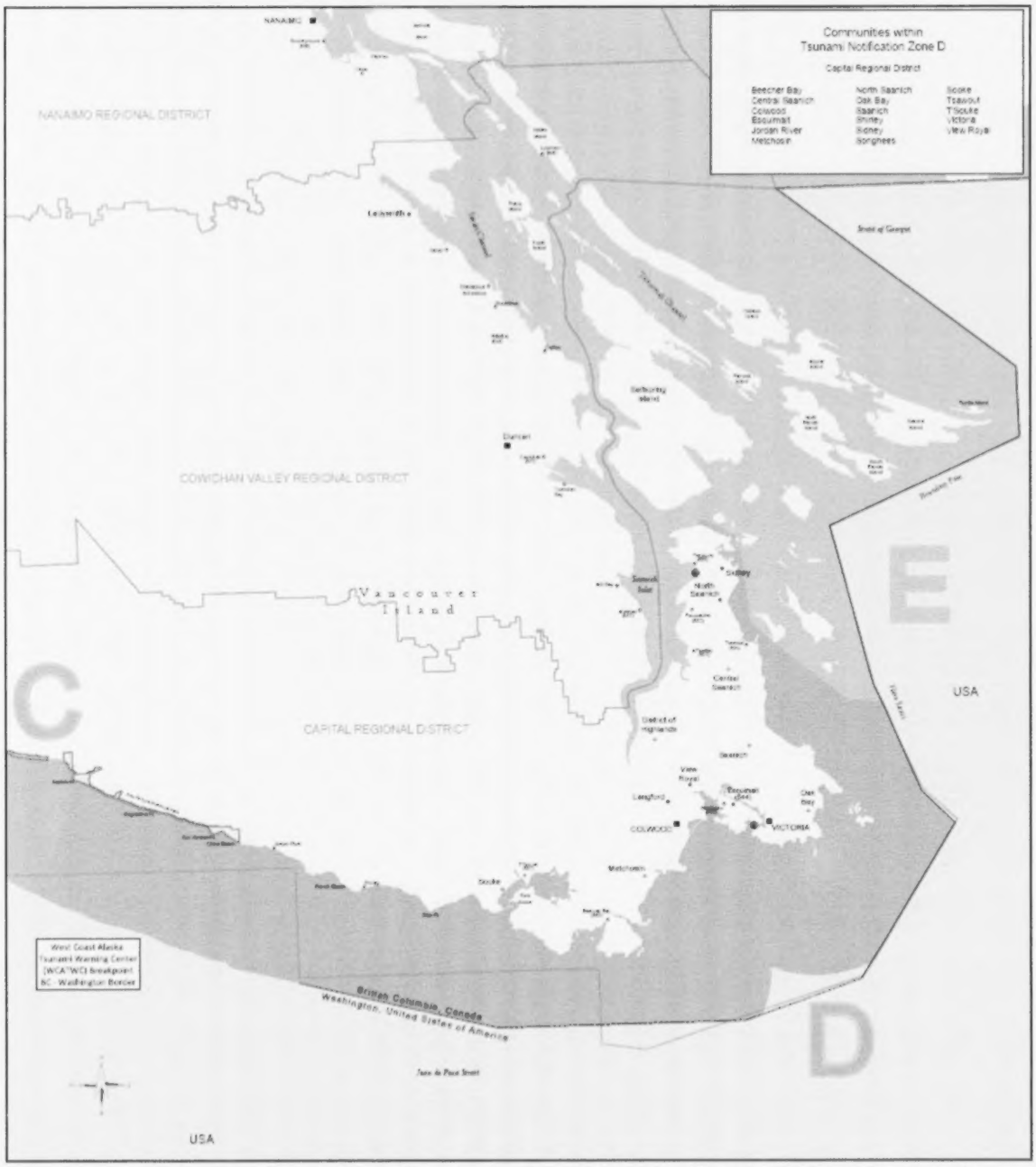

Figure 6: Zone D, the Juan de Fuca Strait from Jordan River to Greater Victoria including the Saanich Peninsula

Zone E

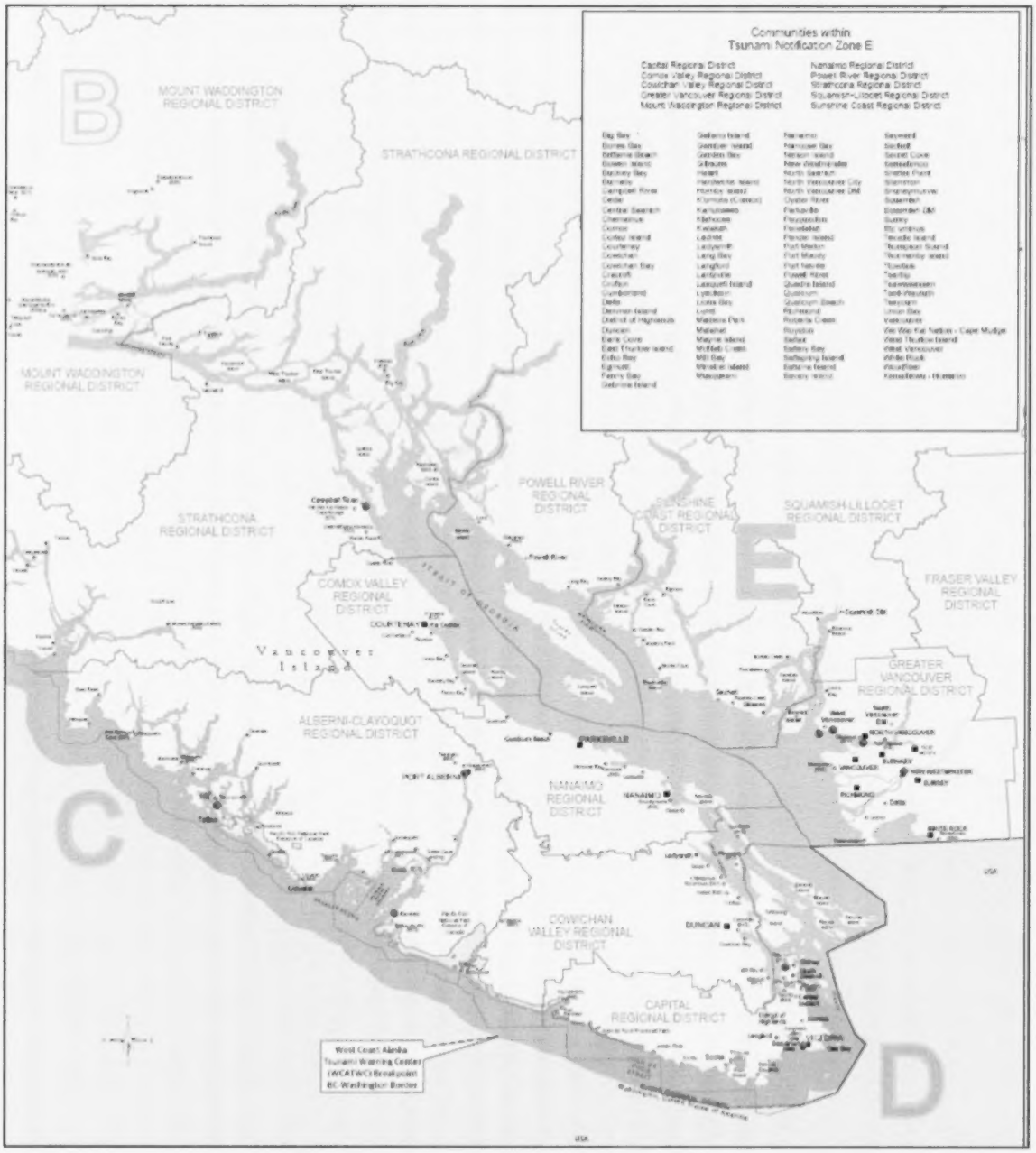

Figure 7: Zone E, the Strait of Georgia including the Gulf Islands, Greater Vancouver and Johnstone Strait

Appendix 4: Sample Templates of BC-Specific Tsunami Messages

Warning

BC BULLETIN NUMBER XXXX

THIS IS AN IMPORTANT BULLETIN FROM THE PROVINCIAL EMERGENCY NOTIFICATION SYSTEM. A LARGE EARTHQUAKE HAS OCCURRED IN THE PACIFIC BASIN NEAR XXXXX. THE NATIONAL TSUNAMI WARNING CENTRE HAS ISSUED A TSUNAMI WARNING THAT INCLUDES THE FOLLOWING ZONES OF COASTAL BRITISH COLUMBIA:

ZONE A - THE NORTH COAST AND HAIDA GWAII

ZONE B - THE CENTRAL COAST AND NORTHWEST VANCOUVER ISLAND COAST, INCLUDING KITIMAT, BELLA COOLA AND PORT HARDY.

ZONE C - THE OUTER WEST COAST OF VANCOUVER ISLAND FROM CAPE SCOTT TO PORT RENFREW

ZONE D - THE JUAN DE FUCA STRAIT FROM JORDAN RIVER TO GREATER VICTORIA, INCLUDING THE SAANICH PENINSULA

AT THIS TIME IT IS BELIEVED THAT A TSUNAMI HAS BEEN GENERATED. THE TSUNAMI MAY IMPACT LOW LYING COASTAL AREAS IN THESE ZONES. LOCAL GOVERNMENTS IN THESE ZONES ARE URGED TO ACTIVATE THEIR EMERGENCY PLANS AND IMMEDIATELY BEGIN EVACUATION OF IDENTIFIED AREAS AT RISK FOR TSUNAMI IMPACTS. UPDATED INFORMATION WILL BE PROVIDED AS SOON AS IT IS AVAILABLE.

NO OTHER ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK. REPEAT, NO OTHER ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK.

THIS MESSAGE IS ISSUED FOR INFORMATION PURPOSES ONLY FOR:

ZONE E - THE STRAIT OF GEORGIA INCLUDING THE GULF ISLANDS, GREATER VANCOUVER AND JOHNSTONE STRAIT.

Advisory

BC BULLETIN NUMBER XXXX

THIS IS AN IMPORTANT BULLETIN FROM THE PROVINCIAL EMERGENCY NOTIFICATION SYSTEM. A LARGE EARTHQUAKE HAS OCCURRED IN THE PACIFIC BASIN NEAR XXXXX. THE NATIONAL TSUNAMI WARNING CENTRE HAS ISSUED A TSUNAMI ADVISORY THAT INCLUDES THE FOLLOWING ZONES OF COASTAL BRITISH COLUMBIA:

ZONE A - THE NORTH COAST AND HAIDA GWAII

ZONE B - THE CENTRAL COAST AND NORTHWEST VANCOUVER ISLAND COAST, INCLUDING KITIMAT, BELLA COOLA AND PORT HARDY.

ZONE C - THE OUTER WEST COAST OF VANCOUVER ISLAND FROM CAPE SCOTT TO PORT RENFREW

ZONE D - THE JUAN DE FUCA STRAIT FROM JORDAN RIVER TO GREATER VICTORIA, INCLUDING THE SAANICH PENINSULA

AT THIS TIME IT IS BELIEVED THAT A TSUNAMI HAS BEEN GENERATED THAT COULD CREATE STRONG CURRENTS OR WAVES IN HARBOURS AND COASTAL AREAS. LOCAL GOVERNMENTS IN THESE ZONES ARE URGED TO ACTIVATE THEIR EMERGENCY PLANS AND TO CONSIDER EVACUATING MARINAS, BEACHES AND OTHER AREAS AT RISK. UPDATED INFORMATION WILL BE PROVIDED AS SOON AS IT IS AVAILABLE.

NO OTHER ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK. REPEAT, NO OTHER ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK.

THIS MESSAGE IS ISSUED FOR INFORMATION PURPOSES ONLY FOR:

ZONE E - THE STRAIT OF GEORGIA INCLUDING THE GULF ISLANDS, GREATER VANCOUVER AND JOHNSTONE STRAIT

Watch

BC BULLETIN NUMBER XXXX

THIS IS AN IMPORTANT BULLETIN FROM THE PROVINCIAL EMERGENCY NOTIFICATION SYSTEM. A LARGE EARTHQUAKE HAS OCCURRED IN THE PACIFIC BASIN NEAR XXXXX. THE NATIONAL TSUNAMI WARNING CENTRE HAS ISSUED A TSUNAMI WATCH THAT INCLUDES THE FOLLOWING ZONES OF COASTAL BRITISH COLUMBIA:

ZONE A - THE NORTH COAST AND HAIDA GWAII

ZONE B - THE CENTRAL COAST AND NORTHWEST VANCOUVER ISLAND COAST, INCLUDING KITIMAT, BELLA COOLA AND PORT HARDY.

ZONE C - THE OUTER WEST COAST OF VANCOUVER ISLAND FROM CAPE SCOTT TO PORT RENFREW

ZONE D - THE JUAN DE FUCA STRAIT FROM JORDAN RIVER TO GREATER VICTORIA, INCLUDING THE SAANICH PENINSULA

AT THIS TIME IT IS NOT KNOWN IF A TSUNAMI HAS BEEN GENERATED. LOCAL GOVERNMENTS IN THESE ZONES ARE URGED TO ACTIVATE THEIR EMERGENCY PLANS AND STANDBY FOR FURTHER INFORMATION. UPDATED INFORMATION WILL BE PROVIDED AS SOON AS IT IS AVAILABLE.

NO OTHER ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK. REPEAT, NO OTHER ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK.

THIS MESSAGE IS ISSUED FOR INFORMATION PURPOSES ONLY FOR:

ZONE E - THE STRAIT OF GEORGIA INCLUDING THE GULF ISLANDS, GREATER VANCOUVER AND JOHNSTONE STRAIT

Information Statement

BC BULLETIN NUMBER XXXX

THIS IS AN IMPORTANT MESSAGE FROM THE PROVINCIAL EMERGENCY NOTIFICATION SYSTEM. A LARGE EARTHQUAKE HAS OCCURRED IN THE PACIFIC BASIN NEAR XXXXX.

THE NATIONAL TSUNAMI WARNING CENTRE HAS ADVISED THAT NO ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK FROM THIS EVENT. REPEAT, NO ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK FROM THIS EVENT.

THIS MESSAGE IS ISSUED FOR INFORMATION PURPOSES ONLY. THIS IS THE ONLY MESSAGE THAT WILL BE ISSUED FOR THIS EVENT.

Cancellation

BC BULLETIN NUMBER XXXX

THIS IS AN IMPORTANT BULLETIN FROM THE PROVINCIAL EMERGENCY NOTIFICATION SYSTEM. A LARGE EARTHQUAKE HAS OCCURRED IN THE PACIFIC BASIN NEAR XXXXX. THE NATIONAL TSUNAMI WARNING CENTRE HAS ISSUED A CANCELLATION FOR ALL WATCH, ADVISORY AND WARNING NOTICES FOR COASTAL BRITISH COLUMBIA, THAT WERE ISSUED FOR THIS EVENT.

NO ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK. REPEAT, NO ZONES OF COASTAL BRITISH COLUMBIA ARE AT RISK.

THE PROVINCE IS STANDING DOWN ITS OPERATIONS CENTRES EFFECTIVE IMMEDIATELY.

THIS IS THE FINAL BULLETIN THAT WILL BE ISSUED FOR THIS EVENT.

Appendix 5: Acronyms, Glossary of Terms and Resources

Acronyms

Although organizational acronyms are generally spelled out the first time they are used in this document, the following listing is provided for reference:

WCATWC	West Coast and Alaska Tsunami Warning Center. Obsolete name; see NTWC
CCG	Canadian Coast Guard, Canada Department of Fisheries and Oceans Canada
CHS	Canadian Hydrographic Service, Department of Fisheries and Oceans Canada
DND	Department of National Defence
ECC	Emergency Coordination Centre, Emergency Management BC
FNESS	First Nations' Emergency Services Society
GSC	Geological Survey of Canada, Natural Resources Canada
AANDC	Aboriginal Affairs and Northern Development Canada
IOS	Institute of Ocean Sciences, Department of Fisheries and Oceans Canada
RJOC	Regional Joint Operations Centre, Department of National Defence
JRCC	Joint Rescue Coordination Centre, Department of National Defence/Canada Coast Guard
JTFP	Joint Task Force Pacific, Department of National Defence
MCTS	Marine Communications and Traffic Services Centre, Canada Coast Guard
NAVCAN	Nav Canada (air traffic control organization)
NRCAN	Natural Resources Canada
NTWC	National Tsunami Warning Center
EMBC	Emergency Management BC, Ministry of Justice
PGC	Pacific Geoscience Centre, Sidney, BC
PEP	Provincial Emergency Program. Obsolete name; see EMBC
PS	Public Safety Canada
RCMP	Royal Canadian Mounted Police
ROC	Regional Operations Centre, Canadian Coast Guard
RMIC	Regional Marine Information Centre, Canadian Coast Guard

Glossary of Related Terms

Breakwater: An offshore structure such as a wall that is used to protect a harbour or beach from the force of waves.

Estimated time of arrival (ETA): Time of tsunami arrival at a fixed location, as estimated from modelling the speed and refraction of the tsunami waves as they travel from the source.

Inundation: Horizontal distance traveled inland by the tsunami from the high tide line.

Low tide: The lowest water level reached during a tide cycle.

Rise: The upward change or elevation in sea level associated with a tsunami, hurricane, tide, or long-term climatic effect. Sea level: 1) The height of the sea compared to tidal fluctuations, averaged over a long period of time. Sea level can change over the years. 2) The level of the surface of the sea, especially its position midway between mean, high and low water.

Run-up: the maximum elevation above sea level of a tsunami at the limit of onshore penetration.

Tidal wave: The wave motion of the tides. This term should not be used to refer to a tsunami.

Tide: The rhythmic, alternate rise and fall of the surface (or water level) of the ocean, and of bodies of water connected with the ocean such as estuaries and gulfs, occurring twice a day and resulting from the gravitational attraction of the moon (and, in lesser degrees, of the sun) acting unequally on different parts of the rotating earth.

Tide gauge: A device for measuring the height (rise and fall) of the tide; an instrument for automatically making a continuous graphic record of tide height versus time.

Travel time: Time required for the first tsunami wave to propagate from its source to a given point on a coastline.

Tsunami: Japanese term meaning wave ("nami") in a harbour ("tsu"). A series of travelling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor. A tsunami is an ocean wave produced by a submarine earthquake, landslide, or volcanic eruption. These waves may reach enormous dimensions and have sufficient energy to travel across entire oceans. They proceed as ordinary gravity waves with a typical period between 5 and 60 minutes. Tsunamis become steeper and increase in height as they approach shallow water, inundating low-lying areas. Where local submarine topography causes extreme steeping, they may break and cause great damage. The popular term, tidal wave, is incorrect because tsunamis have no connection with tides.

Tsunami damage: Loss or harm caused by a destructive tsunami. More specifically, the damage caused *directly by tsunamis* can be summarized into the following categories:
1) deaths and injuries;
2) houses destroyed, partly destroyed, inundated or flooded;
3) other property damage and loss;
4) boats washed away, damaged or destroyed;
5) lumber washed away;
6) marine installations destroyed; and
7) damage to public utilities, such as railroads, roads, electric power plants, water supply installations, etc.

Indirect secondary tsunami damage can be:
1) fire damage to houses, boats, oil tanks, gas stations and other facilities;
2) environmental pollution caused by drifting materials, oil or other substances; and/or
3) outbreak of disease of epidemic proportions that could be serious in densely populated areas.

Tsunami effect: The result, consequence, outcome or aftermath of a tsunami disaster.

Tsunami hazard: Danger to life and property from a tsunami.

Tsunami messages: Messages that contain tsunami information and are disseminated in many ways. This includes the distribution of NTWC messages or BC-specific tsunami messages. This term replaces the commonly used term 'PENS messages'.

Tsunami preparedness or mitigation: Readiness of plans, methods, procedures and actions taken by government officials and the general public for the purpose of minimizing potential risk and mitigating the effects of future tsunamis.

Tsunami risk: Potential loss or injury due to a tsunami.

Tsunamigenic: Having the potential or demonstrated capability to generate a tsunami, e.g., a tsunamigenic earthquake or a tsunamigenic landslide.

Wave height: The vertical distance of a tsunami wave above mean ocean level.

Resources

- NTWC: http://ntwc.arh.noaa.gov
- EMBC (Static information): www.embc.gov.bc.ca
- EMBC (Current situation): www.emergencyinfobc.gov.bc.ca
- Environment Canada: www.weather.gc.ca
- Canadian Tidal information: www.tides.gc.ca